SS521-AJ-PRO-010

0910-LP-751-2700

# Guidance For Diving In Contaminated Waters

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IN REPLY TO

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Subj: APPROVAL OF SS521-AJ-PRO-010, GUIDANCE FOR DIVING IN CONTAMINATED WATERS TECHNICAL MANUAL

Encl: (1) SS521-AJ-PRO-010, Guidance for Diving in Contaminated Waters Technical Manual

1. The Guidance for Diving in Contaminated Waters Technical Manual is approved for use.

2. The purpose of this manual is to provide general guidance and basic procedures for diving in contaminated water. Because of the wide variability in contaminants, potential exposure levels and other variables, only general guidance can be provided. Supervisory personnel are encouraged to contact local agencies to obtain information on local water contaminants and hazards, and contact the Office of the Supervisor of Diving (00C3B) directly for specific guidance.

3. NAVSEA 00C3 POC is LCDR Paul Fleischman, SEA 00C32, at commercial (202) 781-3821, fax (202) 781-4588, DSN 326-3821.

R. C. Whaley
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By Direction

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## CERTIFICATION STATEMENT

This is to certify that responsible NAVSEA activities have reviewed the above identified documentate for acquisition compliance, technical coverage, and printing quality. This form is for internal NAVSEA management use only, and does not imply contractual approval or acceptance of the technical manual by the Government, nor relieve the contractor of any responsibility for delivering the technical manual in accordance with the contract requirement.

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# Table of Contents

CHAPTER 1

# Introduction, Scope, And Purpose

## 1-1 INTRODUCTION

Contaminated water is defined as water which contains any chemical, biological, or radioactive substance which poses a chronic or acute health risk to exposed personnel. Some degree of contamination and/or pollution is evident in practically every body of water in the world. The contamination may be naturally occurring or come from a variety of sources including terrorist acts, leaking vessels, industrial discharges and/or sewer effluent. However, much of the contamination that enters the water is not readily apparent. The biggest concern is from relatively enclosed bodies of water, such as lakes, rivers, or harbors which are within close proximity to large populations and wrecks, where contamination can accumulate and/or concentrate.

These contaminants could present a potential health risk to Navy divers and may additionally impact mission and operational readiness. The effects on personnel may become evident immediately (acute) or may be delayed for many years (chronic) especially in the case of exposures to carcinogenic substances. For most microbiological exposure, illness will not develop for several hours after diving and could possibly be delayed for days. With the exception of chemical/biological warfare agents, acute toxicity and/or incapacitation is unexpected for most chemical exposures. However, chronic sub-toxic exposure to a variety of chemical hazards may effect illnesses such as cancer, neurodegenerative disease, hormonal disregulation and others.

1-1.1 **Purpose.** The purpose of this manual is to provide general guidance and basic procedures for diving in contaminated water. Because of the wide variability in contaminants, potential exposure levels and other variables, only general guidance can be provided. Supervisory personnel are encouraged to contact local agencies to obtain information on local water contaminants and hazards.

1-1.2 **Standard Military Syntax.** This manual utilizes standard military syntax as pertains to permissive, advisory, and mandatory language. Word usage and intended meaning in this manual is as follows:

a. “Shall” has been used only when application of a procedure is mandatory.

b. “Should” has been used only when application of a procedure is recommended.

c. “May” and “need not” have been used only when application of a procedure is discretionary.

d. “Will” has been used only to indicate futurity; never to indicate any degree of requirement for application of a procedure.

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CHAPTER 2

# Contaminants And Hazards

## 2-1 GENERAL

The three types of contaminants divers can expect to encounter are chemical, biological, and radiological. The potential routes of exposure for divers are inhalation, ingestion, absorption, and impingement (forcing of material into the body, such as through a wound). Unless the response is to a specific incident, the availability of quantitative data on the contaminants present in any specific body of water is problematic. Real-time, or even near real-time, water analysis is not currently feasible. If a specific contaminant is suspected, information on various sources are available such as Material Safety Data Sheets (MSDS), shipping manifests, or via sampling and analysis.

## 2-2 BIOLOGICAL CONTAMINANTS AND HAZARDS

Biological contaminants come from humans and animals, urban and industrial sewage, marine and fresh water organisms, commercial ships, hazardous waste sites, marinas, and agricultural runoff. The main source of biological contaminants in water is human sewage. The environmental fate of most pathogens in water is unknown. It is prudent to assume water bodies contain the microbiological organisms of diseases present in a local population unless confidence is high in the effectiveness of the local wastewater treatment facilities. Such confidence is unjustified in underdeveloped areas and even in CONUS after an unusually heavy rainfall. Biological agents are divided into two broad categories, pathogens and toxins.

**NOTE** **Both Chemical And Biological Contaminants Tend To Concentrate In Sediment Rather Than In The Water Column.**

**2-2.1 PATHOGENS.** Pathogens are infectious agents that cause disease in man, animals, or plants. These include bacteria, viruses, and parasites. These are commonly referred to as germs. While the vast majority of microorganisms are harmless or even helpful, there are many naturally occurring pathogens which are harmful to humans. Pathogens cause disease (infection) by entering the body through lungs, digestive tract, and through the skin and mucous membranes of body openings. Once they enter the body, pathogens multiply, overcoming the body's natural defenses, and produce disease. Symptoms most commonly associated with pathogen infection include upper respiratory flu or cold like symptoms, vomiting, diarrhea, pneumonia, or skin lesions. Some pathogens cause nervous system damage such as headache, paralysis, convulsions, or coma.

Viruses are the smallest of the all biological agents able to reproduce. They are incapable of independent life, since they are only genetic material (DNA or RNA) and some encapsulating proteins. They can be dangerous when they enter a human cell, and "hijack" the contents to reproduce themselves. Smallpox and influenza are examples of viruses. Viruses are difficult to detect, and most hospital laboratories are not equipped to do so routinely. Viruses are difficult to treat after exposure, since they are not usually susceptible to common drugs. Some virus protection can be gained by prior immunization, e.g., Hepatitis A; but no vaccines exist for most viruses.

Bacteria are living microorganisms. Unlike viruses and rickettsias, they are capable of reproduction outside living cells. If they enter the body and if the victim is not properly treated, the microorganism will multiply and incapacitate the host. Bacteria can be found in almost any environment. Eschericia coli (E. coli) is a well known bacteria which is commonly associated with contamination of processed meat products. Some strains of E. coli are common inhabitants of the human intestine, and thus are used as an indicator of human feces and to open/close public beaches. Examples of diseases caused by bacteria are cholera and anthrax. Seawater is estimated to contain up to a million bacteria per cubic centimeter. Bacteria sometimes concentrate in a thin layer on the water surface, or a thin layer on the top of sediment.

“Parasites are single-celled or multi-celled organisms that live and feed on or in another animal. Well-known examples of human parasites are malaria and tapeworms. Most parasites are acquired by ingestion (such as eating raw meat) but some can gain entry into humans by skin contact either on land or in the water. Most water dwelling parasites that can cause disease in humans are found in tropical fresh water (as found in Central and South America and Southeast Asia). Salt water parasites rarely cause more than a rash and itching. Still, when working in areas where parasites are known to exist, contact can be prevented or minimized in most cases by wearing protective clothing (wet suit or skin are usually adequate) and bathing soon after surfacing.”

**2-2.2** **TOXINS.** Toxins are poisonous substances produced by microorganisms (pathogens), plants, or some animals. Some toxins can be chemically synthesized or artificially produced with genetic engineering techniques. Toxins exert their lethal or incapacitating effects by interfering with certain cell and tissue functions. Neurotoxins disrupt nerve impulses while cytotoxins destroy cells by disrupting cell respiration or metabolism. There is a vast range of signs and symptoms associated with toxin exposure which makes diagnosis extremely difficult.

Algal blooms, such as those responsible for “Red Tide,” produce toxins which are released into the water. Not all harmful algal blooms (HABs) are red - some are yellow, green and orange. These toxins can cause illness such as cognitive impairment as well as gastrointestinal, respiratory, and dermal distress. Algal outbreaks of human concern are usually associated with large fish kills. Common symptoms one might experience when exposed to these toxins are coughing, eye and skin irritation, runny nose, numbness around the mouth and nausea.

**2-2.3** **Blood Borne Pathogens.** Though many of these pathogens are viruses they are addressed separately since they are generally passed from person to person through direct contact with an infected person’s bodily fluids. These infectious blood borne diseases, e.g., HIV and hepatitis, are most likely to occur when an operation involves the recovery of human remains. Divers may also be exposed through inadvertent contact with potentially infected material such as hypodermic needles or open cuts. Most known infectious agents pose a minimal risk to divers since the agents are fragile and do not survive long outside a host. However, the Hepatitis C virus is less fragile, but infectivity in underwater recovery situations is expected to be low. Divers should complete the series of the standard immunizations required for healthcare workers, including those for Hepatitis A and B virus as well as tetanus. Personnel should be trained in exposure control and safe handling of potential infected material, similar to the manner recommended for healthcare workers. Besides the immediate medical concerns, the fatigue and mental health issues associated with the recovery of human remains should be considered as part of operational planning.

## 2-3 INDUSTRIAL TOXIC/CHEMICAL CONTAMINANTS AND HAZARDS

Based on the number of Material Safety Data Sheets now available, it appears that more than 5,000,000 chemicals are in commercial use worldwide. Chemicals vary widely in availability, solubility, toxicity, and permeability. Generally, as it relates to diving, little to no information is available on either the acute, or chronic toxicity of these chemicals, or their environmental fate. Again the primary sources of industrial chemical contamination are industrial spills, urban and industrial sewage, commercial ships, hazardous waste sites and agricultural runoff. It is expected that every body of water in the world is contaminated to some degree. The National Institute of Occupational Safety and Health (NIOSH) publishes a handbook which lists the exposure criteria for approximately 1,500 of the most common chemicals for which a health hazard analysis has been completed. The guide is available for download at *http//www.cdc.gov/niosh/npg/npg.html*. The website also lists contact information to obtain hard copies or a copy on CD ROM for a minimal fee. If the presence of a specific chemical is confirmed, some information may be available to assess the risk. The following paragraphs are a general list of chemicals which divers can expect to encounter.

2-3.1 **HYDROCARBONS.** Hydrocarbons are chemicals composed essentially of atoms of hydrogen and carbon. They range from small and light substances (natural gas) to large and hard to evaporate molecules (coal). In between are a range of solvents, oils, fuels, and the larger polyaromatic hydrocarbons (PAHs). PAHs are about the heaviest hydrocarbons able to evaporate and able to dissolve in water. All the common hydrocarbons are in fact complicated mixtures of chemicals, and will have different compositions in different locations at different times. Even MIL-SPEC diesel fuel, hydraulic oil, and creosote are all complicated hydrocarbon mixtures (with lots of PAHs) having no full chemical specification. Creosote, commonly used as a wood preservative, is a petroleum derivative that contains PAHs and is a known carcinogen. The amount of creosote leaching into adjacent water decreases with time; newer pilings, dock supports, etc. may pose a greater health risk than those in place for several years.

2-3.2 **HEAVY METALS.** Metals in purified form are solids with low potential of being toxic; unfortunately, they are not usually encountered in purified forms. Metals combined with other chemicals can form stable minerals that also have low toxicity. In the marine environment, metals can also exist as dissolved ions, adsorbed into other solids like clay or humus, or chemically combined into an organic compound, such as methyl mercury. Many water quality limits on metals are based on dissolved ions, as that form is considered to carry the greatest hazard to fish. Consistent with that assumption, the usual tests for metals in water initially convert all forms into metal ions.

**2-3.3 POLYCHLORINATED BIPHENYLS (PCBs):** PCBs are materials that were used as paint additives and electrical equipment coolants. PCBs were banned from production and use in 1977 in North America for concern over health effects associated with them. PCBs do not readily decompose and have been discovered in the sediment of many bodies of water. OPNAV Instruction 5100.23 addresses Navy occupational exposure to PCBs. Chloracne is a severe skin condition associated with exposure to PCBs. Prolonged dermal exposure to PCBs is a significant health concern.

## 2-4 CHEMICAL/BIOLOGICAL WARFARE AGENTS

Chemical/Biological warfare agents present an extreme hazard to a diver and every attempt should be made to identify the agent and mitigate the concentration/exposure prior to diving. The U.S. Army Field Manual (FM) 3-9 *Potential Military Chemical/ Biological Agents And Compounds* has information on the chemical makeup and characteristics of specific agents and should be used as the initial reference source if tasked to respond to an incident involving a chemical or biological warfare agent. Distribution of FM 3-9 is limited to military and government agencies. However, it does not contain specific information on the environmental fate of these compounds in sea water. Other available sources of information are other military field and technical manuals, e.g., FM 3-5 *NBC Decontamination* and the Chemical and Biological Information and Analysis Center (CBIAC): Tel: (410) 676-9030 Fax: (410) 676-9703, web address: *http://www.cbiac.apgea.army.mil/*.

## 2-5 RADIOLOGICAL CONTAMINANTS AND HAZARDS

Divers may respond to an emergency situation where the diving area is contaminated with a radiation source, or may be required to perform inspection, repair or maintenance in the fuel pools of nuclear power reactors. Radiological contamination is expected to most likely occur through an accident or intentional terrorist act. All divers must have a thermo luminescent dosimeter (TLD) or similar item, and be told of the locations of radioactive items. Nuclear shipyard divers are experienced and trained in diving near point sources of radiation. Diving within the fuel pools of nuclear power reactors is done internationally by civilian contractors working for private or government-operated power companies.

CHAPTER 3

# Equipment

## 3-1 GENERAL

There is no single equipment configuration or material which will protect the diver under all conditions or from all contaminants. The type of protection needed will be determined by the expected hazard, type of work, the urgency of the work, and the available equipment. The diving support system should include both respiratory and physical protection. The standby diver must be equipped with a level of protection at least equal to that worn by the divers. Additionally, the surface tenders and support personnel may experience as great a hazard as the diver. The mucous membranes are the most vulnerable regions on the body and, assuming intact skin, are essentially the only route microorganisms can enter and infect the body. Therefore, isolating these vital areas from the source of contamination is the primary concern when diving in a biologically contaminated environment. Respiratory and physical protection must be available for surface support personnel. For a wide range of contaminated water diving operations, the use of dry suits composed of vulcanized rubber and a diving helmet, or overpressure breathing system, are the preferred system. However, there will be situations when additional protection will be required.

## 3-2 SCUBA EQUIPMENT

Diving with a standard SCUBA ensemble including a half face mask and a mouthpiece regulator provides very little protection to a diver. The diver’s mouth is in constant contact with the water exposing the diver to contaminants which can enter either around the mouthpiece or via water refluxed through the exhaust valve. Inhalation of microscopic water droplets from the area of the regulator mouthpiece and from its exhaust valve may cause contamination to go to the lungs and on to the bloodstream. Where water is suspected of being contaminated, use of standard SCUBA equipment should be strongly discouraged.

3-2.1 **FULL FACE MASK.** If the primary hazard is microbial, a full-face mask may reasonably protect mucous membranes in the eyes, nose, and mouth. Both NOAA and the EPA use a full-face mask for contaminated water diving. An obvious advantage in using this approach is the portability and relative ease of use of a full-face mask. Full-face masks can be configured to operate with compressed gas SCUBA tanks, a configuration that affords a diver unencumbered freedom of movement and provides moderate protection. Most full-face masks can also be configured to operate from surface-supplied compressed gas which affords greater endurance but restricts mobility compared to SCUBA. A recent international diving survey found no commercial diving operations using full-face masks for contaminated water diving. A full face mask which incorporates a positive-pressure regulator will help eliminate water entering the mouth, but does not resolve the droplet inhalation concern. Additionally, full-face masks offer no protection for the diver’s head, neck, or ears, all of which are potential sites for exposure to waterborne hazards.

**3-2.2 CLOSED/SEMI-CLOSED CIRCUIT REBREATHERS.** Using a full face mask with a rebreather, such as the MK 16 or MK 25, would mitigate exposure through exhaust valve reflux and allow for complete encapsulation of a diver in a protective over suit. Accordingly, in some scenarios use of these apparatus should be considered.

## 3-3 SURFACE SUPPLY DIVING SYSTEMS

**3-3.1 MK 20.**The MK 20 offers an added level of protection over half-masks and mouthpiece regulators. Operating the MK 20 in the positive-pressure mode will lessen the likelihood of water leaking into the mask. However, some water is likely to enter either under a poor-fitting face seal or as reflux through the exhaust valve. Therefore, the MK 20 and other full-face masks should not be considered when high levels of protection are necessary. When using a MK 20 to dive in moderately contaminated water, the side block assembly should be employed for emergency gas supply.

**3-3.2 MK 21 Diving Helmets.**By sequestering the diver from the water column the MK 21 surface supplied hard hat equipped with the double exhaust kit, when mated to a vulcanized dry suit offers the greatest protection for divers in contaminated water. Unlike masks, the MK 21 is able to protect a diver’s entire head, including his ears. However a problem frequently reported with the MK 21 is reflux of water through the exhaust valve mechanism. Even when outfitted with the double exhaust kit for diving in contaminated water, some water occasionally leaks back into the helmet. This allows some water to accumulate in the oral/nasal mask portion of the helmet so that when the diver triggers the demand regulator with his next breath, he aspirates and/or ingests an atomized spray of water containing contaminants from the water column. This problem is most often reported in water with high particulate matter content such as suspended silt and sediment. For the MK 21, leakage of water into the helmet can be mitigated by adjusting the dial-a-breath to a slight free-flow when the diver reaches the bottom to effect a slight positive pressure.

Another concern reported with the MK 21 occurs during use in water heavily contaminated with petroleum products. The exhaust whiskers of the double exhaust kit are manufactured from a dipped latex procedure, and are highly susceptible to degradation by petroleum products, as well as many other solvents. They will require frequent replacement to maintain the integrity of the helmet. Some operators have had to perform annual maintenance procedures on the MK 21 daily while diving in such environments. Ample supplies of spare parts including o-rings and double exhaust kits should be available when preparing to dive in water contaminated with petroleum-based materials. NAVSEA is currently pursuing replacement of these soft goods with more resilient materials. Leakage into the oral nasal mask will occur at any depth when the head is moved from the upright position. Leakage can be minimized by opening the steady flow slightly. Adjusting the dial-a-breath has no influence on whether or not leakage occurs.

3-3.3 **Umbilicals.**Standard diver's air supply hose is comprised of nitrile with a neoprene outer shell. This combination is reasonably resistant to many chemicals. However, prolonged exposure to concentrated chemical contaminants, especially solvents, may lead to decomposition of the hose. Careful inspection of hoses is warranted before and after diving in contaminated water.

## 3-4 DIVING DRESS

The type of diving dress selected will be based upon several considerations such as the water temperature, level of contamination, and type of contaminant. No suit can protect a diver from all substances, however a dry suit with attached gloves connected to a positive pressure (free flow) helmet is the best protection for a diver in contaminated water. Coated exterior fabric dry suits may be difficult to decontaminate. Some contaminants may cause such rapid deterioration of material, or may be so difficult to clean from the diving dress, that a new suit and other equipment may be needed for each dive. This increase in required equipment should be included in planning operations. The type of dress chosen should have strength, flexibility, ease of decontamination, and, most importantly, chemical resistance. It should preclude any contact between the human body and the contaminants.

3-4.1 **WET SUITS.** Wet suits offer little to no protection while diving in contaminated water. The skin is directly exposed to the contaminants in the water while foam neoprene can absorb large amounts of contaminated water making decontamination difficult. In addition some contaminants can degrade foam neoprene. Wet suits are not appropriate when diving in moderately contaminated water or when an acute risk exists.

3-4.2 **DRY SUITS.**Dry suits, either variable or constant volume, are appropriate for diving operations in contaminated water. A one-piece dry suit with incorporated hood and gloves is preferred with the goal of minimizing the number of penetrations. Vulcanized dry suits offer substantial protection from all microbiological hazards and from many chemical hazards for extended periods of time. The Viking HD, or equivalent vulcanized rubber dry suit, should be used for all diving in contaminated water. The dry suit should have a neck dam that creates a watertight seal directly to the MK 21. Intact skin is susceptible to many hazards including PAHs (in high concentrations in petroleum products), PCBs, pesticides, creosote, and some heavy metals. Isolating a diver in a dry suit is highly recommended when these materials are present. Divers may experience some leakage of water if a suit is not properly fitted. Care should be taken to ensure divers and dry suits are matched appropriately by size.

Viking and Gates publish data for resistance of their respective suits to a host of chemicals. When concentrations of known contaminants are available this information should be referenced for maximum safe dwell times. Consideration of the durability of other components of the diving ensemble, such as the helmet, gloves, umbilical etc., should be taken into account when determining dwell times. Evidence a suit is being degraded by contaminants are swelling of the material, color changes, tackiness, stiffness when dry, and exposure of underlying fabric. Suits demonstrating any of these changes should not be reused.

**3-4.3** **SUIT UNDER SUIT (SUS).** NOAA and the EPA developed the Suit-Under-Suit system in house and it is not available commercially since it requires an enormous supply of fresh water. It should be considered for extremely contaminated water where the time and logistics are available to acquire and support its use. The suit-under-suit consists of a tight-fitting, thick neoprene suit with attached booties worn under a modified vulcanized dry suit. The suits are joined at the neck by a clamp. This creates a closed space between the two suits. Clean fresh water is supplied to enter the outer suit via a valve at the diver's chest. The space between the two suits is flooded with clean water. Exhaust valves on one arm and at both ankles allow water to exit. A garment of tight-fitting heavy fabric is worn over the SUS. This protects against chafing and tearing, and prevents the suit from blowing up. If the SUS is damaged, the positive pressure of clean water prevents contaminated water from coming in contact with the diver. If contaminated water gets in, isolation of the diver's head will provide protection for the eyes and respiratory system, and prevent inhalation and ingestion of contaminated water droplets. Isolating the diver's head and life-support system from his body and suit environment is highly desirable when positive pressure is used, and essential when in demand mode. "For additional information contact NAVSEA 00C32, (202) 781-3821 DSN 326-3821."

**3-4.4** **GLOVES.** Chemically resistant waterproof gloves should be used when diving in contaminated water. Viking manufactures a three-finger glove comprised of similar material to their dry suit. Additionally, commonly available butyl or nitrile rubber five-fingered gloves offer satisfactory chemical resistance while providing greater dexterity than three-finger options. Gloves should be positioned over cuff rings on the sleeves of the Viking HD dry suit. Depending on the nature of the diving job, an over-glove may be used to protect against chafing and punctures. In cold water, thermal under-gloves may be necessary. For extra security, gloves should be taped or zip tied to the dry suit sleeve above the cuff ring. Gloves should not be equalized with dry suits to minimize the possibility of contamination entering the entire suit in the event of a tear.

**3-4.5** **OVERSUITS.** If it is reasonable to expect to encounter bulky, adherent contaminants during a dive, a disposable oversuit, e.g., TYVEX®, may be used. Such disposable hazardous material protective suits can be secured to a diver after he has been outfitted with the entire diving rig. No effort to make the oversuit watertight should be attempted, for such an attempt may complicate the dive by creating air pockets.

## 3-5 COMPRESSORS

A concern for conducting diving operations in contaminated water is compressed gas supply. Since compressors are often used on site to compress gas as needed, volatilized components of waterborne hazards can potentially enter an on-site compressor and contaminate the gas supply. Historically, the primary source of contaminated air samples has been from compressor intakes not being positioned upwind or away from the source of contamination, e.g., fuel oils, hydrocarbons. Operations supervisors, therefore, should be careful to position compressor intakes upwind of contamination, if possible. Such optimal positioning may not always be feasible or reliable, so compressing gas off the site may be a prudent alternative and may mitigate the chances of contaminants entering diver gas supplies.

CHAPTER 4

# Pre-dive Planning

## 4-1 GENERAL

**NOTE** **Prior to conducting diving in suspected contaminated water, diving supervisors should contact SEA 00C for support in obtaining information on potential levels of contamination, specific procedures, and local support agencies.**

The majority of U.S. Navy diving will occur in water with few obvious signs of contamination. In the dive planning stage, operational risk management (ORM) techniques (OPNAVINST 3500.39A) should be used to balance the risks of an operation against the potential risks to personnel and equipment. The potential routes of exposure for divers and topside personnel to chemical/biological contamination are inhalation, ingestion, absorption, and impingement. A good risk assessment will identify the expected route(s) of exposure, expected contaminant(s) and reasonable precautions necessary to minimize the exposure to both the diver and topside personnel.

Most chemical hazards to which divers are exposed cause limited immediate effects. For most microbiological exposures, illnesses will develop hours to days after exposure. However, chronic exposure to chemical hazards may cause/effect the occurrence of other illnesses such as cancer. Recognition and identification of substances is of paramount importance if adequate and appropriate monitoring of exposed personnel is to be conducted by medical authorities.

Diving in water heavily contaminated with pathogenic microbes may infect an otherwise seemingly innocuous skin wound. For this reason, divers with preexisting, unhealed wounds should be prevented from diving in contaminated water. Any injuries that they sustain during such diving should require them to exit the water for immediate medical attention.

The expected decompression obligation and decontamination procedures to be implemented should be thoroughly briefed to the dive team during the planning phase. Diving in contaminated water should be scheduled to require no in-water decompression in order to limit the diver's exposure to waterborne hazards. Decontamination and diver undress procedures, within the five-minute time constraint, should be demonstrated to the Diving Officer before attempting dives relying on surface decompression. As described in the decontamination section, decontamination procedures are tedious and may require a prolonged time. Every effort must be taken to ensure thorough decontamination is achieved prior to recompressing divers because introducing contaminants to recompression chambers may present significant health and safety concerns.

**WARNING** **During surface decompression operations, incomplete decontamination of divers may contaminate recompression chambers and present a fire hazard.**

## 4-2 MEASUREMENT AND MONITORING

Reliable analysis of water for chemical and microbiological substances is difficult to obtain. Simply sending the water sample “to the lab” will not give a complete picture of the contaminants present. Most laboratory techniques are not designed to scan for all possible contaminants at once, but rather must be focused narrowly to provide optimum results. Analysis of a water sample for the potential 5,000,000 chemical contaminants is impracticable. Microbiological testing requires entirely different analytical methods than those which detect chemical contaminants. The scope of testing should be limited by prior research of local conditions and concerns. There is also usually a 2 or 3 day lag between sampling and reporting. Tests are available which cover more than one substance, such as 8 metals, or 11 PAHs, at once, for about $100 per sample.

Additionally, depending on the nature of a contaminant, it may float on the surface, suspend in the water column, or accumulate on the bottom. An accurate analysis requires samples throughout the entire water column and adjacent sediment. The validity of samples collected is also likely to be dependent on several other variables which change over time including current, tide, temperature, and weather. The variation in contamination across space and time is simply unknown. For these reasons, real or near-real time water analysis is not currently feasible.

Generally, only a qualitative water quality assessment is possible since a complete and reliable analysis of the contaminants present in the water is difficult, if not impossible, to obtain. Supervisors should obtain as much quantitative information as possible to aid in their assessment. This information may be available from various sources including local water quality management offices, contained in environmental studies or available from local environmental regulation agencies. If a specific contaminant or hazard is suspected, sampling and analysis should be completed prior to commencement of dive operations. The risk assessment should be thorough in order to best protect the diver and topside personnel. Several of the factors that should be considered in this analysis are the nature of the contamination, urgency of the required operations, the natural environmental, type of body of water, and the diving and protective equipment available.

## 4-3 LEVELS OF PROTECTION

Based upon the expected primary source of contamination, the protective ensemble chosen should minimize the exposure route. The following are levels of protective equipment comprised of components currently available on the ANU. The levels are patterned after EPA guidelines for personal protective equipment, with level A being most protective and level D least protective. No scientific testing has been performed on these diving ensembles to evaluate extent of protection, therefore the levels of protection in Table 4-1 are strictly recommendations.

**4-3.1** **LEVEL A.** MK 21 Diving Helmet with Double Exhaust Kit, Vulcanized Rubber Dry Suit with Mating Neck-Dam, Dry Gloves attached to integral cuff rings on dry suit sleeves. Dial-a-breath in MK 21 is to be adjusted while at maximum depth to slight free-flow mode.

**TABLE 4-1.** WATER QUALITY AND PROTECTIVE GEAR RECOMMENDATIONS.

| WATER QUALITY | PROTECTION LEVEL | DECONTAMINATION |
|---|---|---|
| | | |
| Category 1 | A | Yes |
| Category 2 | A or B | Yes |
| Category 3 | A, B or C | No* |
| Category 4 | A, B, C or D | No* |

*Routine post-dive maintenance required.

**4-3.2** **LEVEL B.** MK 20 Full-Face Mask in positive pressure mode, Vulcanized Rubber Dry Suit with Hood, Dry Gloves attached over cuff rings. The side-block assembly is to be used for EGS.

**4-3.3** **LEVEL C.** Any Diving Helmet or Full-Face Mask not used with a dry suit.

**4-3.4** **LEVEL D.** Any UBA with a mouthpiece or T-bit.

**CAUTION Any breach of personal protective equipment used to conduct a dive in contaminated water should result in termination of the dive as soon as feasible to limit exposure to the hazards.**

## 4-4 QUALITATIVE WATER QUALITY CATEGORIES

As part of the ORM process a quantitative analysis of the water quality should be made. Generally this will only be possible if responding to a specific incident where the spilled contaminant is known and quantitative tests are available. In most incidents a qualitative assessment of the water quality is the best assessment that can be made. The following categories were developed by the California Department of Transportation and are broken into four categories.

**4-4.1** **CATEGORY 1.** Highest contamination. Grossly contaminated with concentrated chemical or microbiological contamination. Examples include obvious fuel slicks, aircraft recovery with copious jet fuel present, sewage operations, and human remains recovery. LEVEL A protective gear is strongly recommended.

**4-4.2** **CATEGORY 2.** Moderate contamination. Increased levels of both chemical and microbiological contamination above what is normally expected. LEVEL A protection is recommended unless primary suspect contaminant is microbiological, then LEVEL B is appropriate.

4-4.3 **CATEGORY 3.** Baseline contamination. Baseline contamination is defined as the water quality that is “normally” expected AND which has a demonstrated history of causing no acute effects on divers. Baseline contamination may be different for different locations. A concern may still exist for contaminants that may easily enter the body through the mouth if a full-face mask or helmet is not used. LEVEL C or more protective equipment recommended unless a completed ORM analysis shows use of level D is an acceptable level of risk.

4-4.4 **CATEGORY 4.** No contamination. This includes situations where no contaminated sources are known or expected such as at remote locations offshore. Additional examples are drinking water reservoirs, swimming pools or other bodies of water routinely analyzed for quality. Local water management authorities may dictate what a diver wears in such water so that he does not introduce contaminants in the water supply. Any type of diving apparatus is acceptable for diver protection.

## 4-5 SPECIFIC DIVING SCENARIOS

Certain scenarios can increase the potential exposure to chemical/biological contamination and extra protective measures should be adopted. Table 4-2 describes the recommended protection for the specific diving scenarios described below.

4-5.1 **After Rainfall.** After appreciable rainfall, land-based contaminants may be washed into a watershed basin with the runoff. This phenomenon has been termed “first flush.” Dives planned during or in the days immediately following a large rainfall should anticipate exposure to a variety of chemical and microbiological hazards when diving in an area with a reasonable expectation of “first flush” effects. LEVEL A protection should be employed for such dives. If the concern is only for microbiological contamination, LEVEL B should offer adequate protection.

4-5.2 **Working in Sediment.** Most persistent contaminants with a density greater than water will accumulate in the sediment. Of the analysis of water that has been reported, the sediment routinely has significantly higher levels of both chemical and microbiological contamination than the adjacent water column. This contamination may include heavy metals and PCBs. LEVEL A protective gear should be used for all dives involving sediment disturbance in harbors or other areas with reasonable expectations of prior contamination.

4-5.3 **Points of Discharge.** Water adjacent to points of discharge such as drainage pipes and runoff channels can contain increased levels of contamination. When conducting diving operations within several hundred yards of such sources of water, LEVEL A or B protective gear should be used.

4-5.4 **Working with Hazards.** Several diving scenarios will indicate the need for the use of maximal protective gear to mitigate divers’ health effects from exposure to suspected contaminants. These include diving in gross fuel contamination, such as on leaking vessels or aircraft recovery, as well as working with specific, known hazards, such as creosote

**TABLE 4-2.** RECOMMENDED PROTECTION FOR SPECIFIC DIVING SCENARIOS (FULL DECONTAMINATION RECOMMENDED FOR ALL SCENARIOS.)

| SCENARIO | PROTECTION LEVEL |
|---|---|
| | |
| First Flush | A (or B*) |
| Sediment | A |
| Discharges | A or B |
| Known Hazards | A (or B*) |
| Algal Blooms | A or B |
| Protozoa | A or B |
| Human Remains | A or B |

*Level B appropriate if hazards of concern are microbiological.

soaked wood materials and working with anti-fouling paint. LEVEL A protection should be employed for such dives. If the concern is only for microbiological contamination, LEVEL B should offer adequate protection. If the primary hazard floats on the surface the use of a high pressure spray to clear an area of the waters surface when the divers enter/exit will limit the amount of material to which they are exposed.

4.5.5 **Algal Blooms.** Algae, such as those responsible for "red tide" pose a significant health hazard not only to divers in the water, but also to topside personnel. Health effects include respiratory, dermal, and cognitive changes. Many algal blooms are associated with large fish kills. LEVEL A or B protective gear should be worn when diving in water contaminated with such algae. Also, topside personnel require respiratory and splash protection. Visual discrimination tests are available as an indicator when evaluating divers exposed to Pfiesteria.

4-5.6 **Human Remains Recovery.** For divers and body handlers in the water, every effort should be made to protect personnel from injury and unnecessary exposure to body fluids and tissue. Divers should employ LEVEL A or B protective gear to completely avoid skin and mucous membrane contact with human remains and the water in the vicinity of the remains. If the recovery is to be made around wreckage where there is a reasonable concern for injury, divers should wear reinforced gloves to minimize the chance of introduction of potentially infectious materials to their hands.

## 4-6 SOURCES OF INFORMATION

Information about water quality may be obtained from state and local health agencies. These organizations often have water testing and reporting procedures in place and are often accessible via the Internet. This information usually focuses on microbiological contamination for recreational waters or fishing estuaries, and is available for most coastal states. For OCONUS operations, the Armed Forces Medical Intelligence Center (AFMIC) can provide some information regarding local water quality. Such information may require a few weeks to compile. Requests should be initiated accordingly. Internet availability to AFMIC can be found at: http://mic.afmic.detrick.army.mil. Table 4-3 lists various other points of contact for information on contaminated water diving. Appendix A contains additional reference materials and information sources.

**TABLE 4 - 3.** POINTS OF CONTACT FOR CONTAMINATED WATER DIVING

| Nation | Address | Telephone | Fax |
|---|---|---|---|
| Belgium | Belliardstraat, 14-18 B<br>1040 Brussels BE | [02] 5025080 | Belgium (BE) |
| Canada<br>Note (1) | Environment Canada Emergency Center<br>Place Vincent Massey Hull K1A 0H3<br>CANUTEC Tower C. Place De Ville Ottawa<br>K1A 0N5 | [819] 953-5361 | (819) 997-3742 |
| Denmark | Chemical Laboratory Universitetsparken 2<br>2100 Copenaghen OE<br>2) Poison Information Centre<br>Righsospitalet TA<br>Gensues 20 DK<br>2200 Copenaghen N | [613] 954-5101 | (613) 996-6666 |
| United States<br>Note (2) | National Strike Force Center<br>United States Coast Guard<br>National Strike Force Coordination<br>Elizabeth City, NJ<br>Atlantic Strike Team<br>Atlantic Area Fort Dix, NY<br>Pacific Strike Team Pacific Area Hamilton<br>Field, Navato CA<br>Gulf Strike Team<br>Gulf of Mexico<br>Mobile, AL<br><br>U.S. Environmental Protection Agency<br>National Health and Environmental<br>Effects Research Laboratory<br>http://www.epa.gov/nheerl/<br>1 Sabine Island<br>Gulf Breeze, FL 32561-5299 | (919) 331-6000<br>(609) 724-0008<br>(415) 883-3311<br>(205) 639-6601<br>(850) 934-9242 | (919) 331-6012<br>(609) 724-0232<br>(510) 437-3628<br>(205) 639-6610<br>(850) 934-9201 |
| Germany<br>Note (3) | 1) Wehrwissenschaftliche<br>Materialprofung for Chemical Pollution | | |

**Notes** (1) Canada: Information on hazardous materials can be found in the Workplace Hazardous Materials Information System (WHMIS) which is available at all major Canadian government and civilian agencies.

(2) United States: By contacting one of the listed locations and providing basic identification information of suspected contaminated items, the Strike Force will access its Marine Safety Information System (MSIS). The MSIS is a computer-based system capable of performing a database search for toxic substances and providing information on specific hazards associated with those substances and proper disposal/handling guidance.

(3) Germany: If chemical or radiological pollution occurs when diving, the hygienist of the area, Wehrbereich/Territorialkommando, will identify the toxic substances through the use of special laboratories in the area. If the pollution occurs in Northern Germany along the shoreline of Baltic or the North Sea (Navy), identification of toxic substances will be made by the Territorialkommando Kiel and Wehr-bereichsverwaltung I, Ab, II A3/Afnorth Feldstrabe 70.

## 4-7 PERSONNEL QUALIFICATIONS/ TRAINING

Training is as important as personnel selection. A training program should thoroughly explain contaminants and their properties, precautions, effects of exposure, methods of protection, and emergency procedures. Continuous refresher retraining is imperative to ensure divers remain competent in the procedures and use of equipment. Depending on the type of toxic substance encountered, it may be advisable to introduce short or long term biological and medical surveillance of exposed personnel.

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CHAPTER 5

# DIVE STATION DECONTAMINATION PROCEDURES

## 5-1 DECONTAMINATION

The aim of decontamination is to either rapidly and effectively render contamination harmless or remove it. The goal of systematic decontamination procedures is to limit the spread of the contamination and reduce the levels to the greatest extent possible in order to protect personnel and equipment. The decontamination and monitoring process is unique to each accident/incident. Decontamination techniques may be both physical and chemical. The decontamination methods selected should be tailored to the hazard, responders on scene, location, and equipment available. The tasks performed do not change significantly between different types of contamination but the procedures may vary depending on the nature of the accident/incident and the available equipment. Standard DOD decontamination procedures, as described in various manuals or instructions, e.g., U.S. Army FM 3-5 *NBC Decontamination*, can be effectively modified to work in diving scenarios. Familiarization and platform specific contaminated water diving drills should be conducted routinely. Such drills should encompass all aspects of diving in contaminated water including equipment selection, donning protective equipment, and decontamination procedures.

## 5-2 TOPSIDE PROTECTION

Tenders and other topside personnel may also require protection from hazards while supporting diving operations in contaminated water. A thorough hazard analysis will address the degree of protection required by topside personnel as well as the divers. Every effort should be made to position the “dive station” outside the contaminated area with a transition zone between the work area and the “dive station.” Some degree of contamination of the deck and topside equipment will occur and it is expected the umbilicals and line tenders will come into intimate contact with contaminated water and must be appropriately protected. Depending on the nature of the hazard, topside protection may involve the use of splash protection and face shields, impermeable rainsuits, cartridge respirators, disposable hazardous materials suits or a combination of all of the above. For human remains recovery missions, all body handlers should observe universal medical precautions and avoid unnecessary contact with potentially infectious material. All personnel should wear coveralls, thick disposable gloves, and protective eyewear. The same immunization recommendations for divers apply to tenders. In warm weather, thermal stress can be a severe problem for personnel wearing protective dress. Close monitoring and short rotations of duty may be necessary. Industrial hygiene support from the local military treatment facility, preventive medicine unit, or the Navy Environmental Health Center (NEHC) should be consulted for guidance on the necessity of respiratory protection for topside personnel.

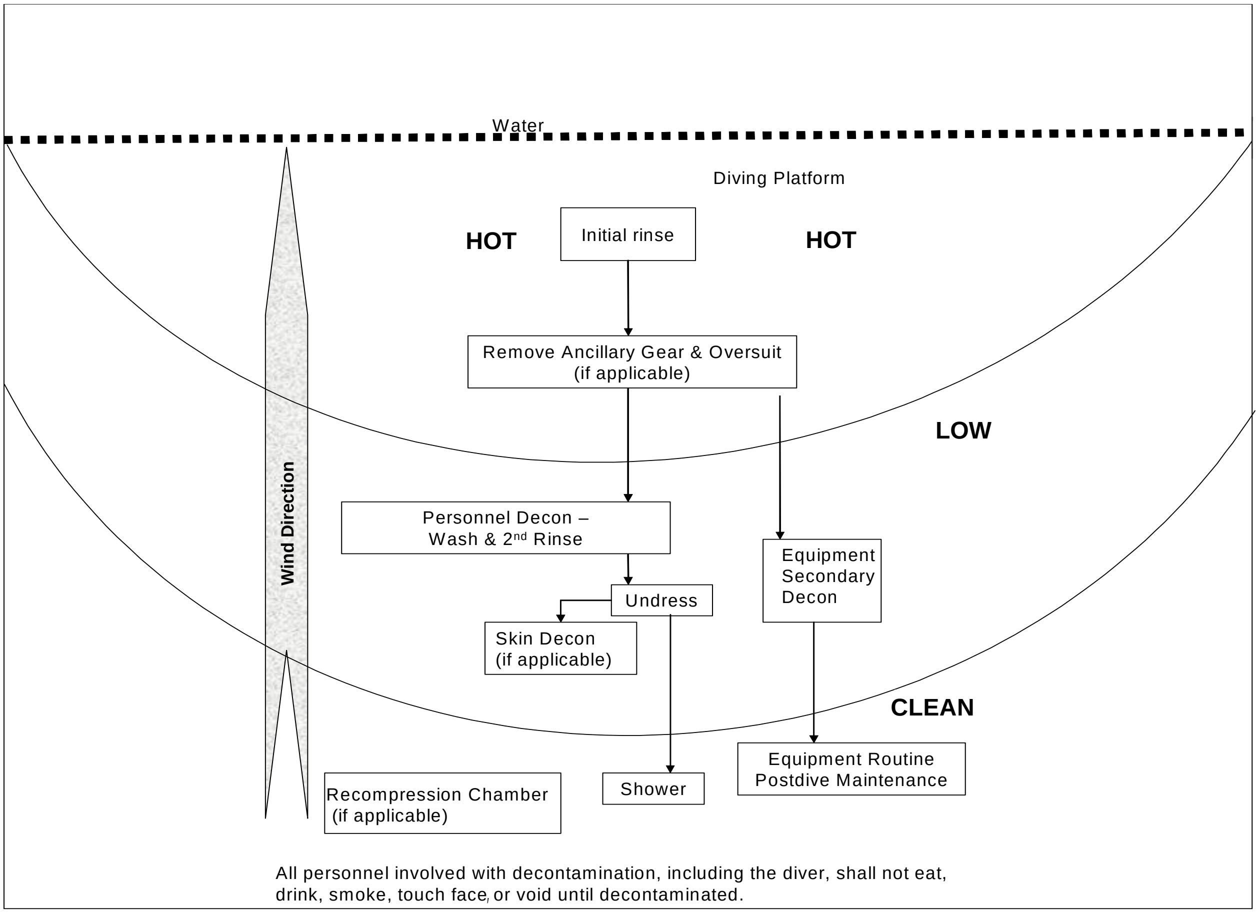


**FIGURE 5 - 1** DECONTAMINATION STATION OVERVIEW

## 5-3 DECONTAMINATION STATION OVERVIEW

Even before diving operations in contaminated water begin, the dive site should be divided into three zones for proper sequestration of contamination throughout the operations, see Figure 5-1. A zone immediately surrounding the point of water entry/exit must be deemed one of "high contamination." The zone to which divers and gear progress after completing their initial decontamination following a successful dive is one of "low contamination." A final zone into which divers progress after they have been decontaminated and had all their diving equipment removed is "clean." If feasible, the clean zone should be positioned upwind from the contaminated zones. Positioning of topside personnel may need to be adjusted to keep from spreading contamination.

### 5-3.1 INITIAL DECONTAMINATION

The initial decontamination step is to spray bulk contaminants off a diver with a high-pressure, clean, fresh water rinse. Use salt water if fresh water is unavailable. In some circumstances, all fluid used to rinse, wash, and re-rinse the diver and equipment needs to be captured for appropriate disposal as hazardous material. In such instances, the decontamination procedure needs to be altered. The diver should not be initially rinsed until he is within a water-impermeable capturing area. Such an area could include sheeting placed on the ground to contain liquids, or a child's wading pool. After all decontamination procedures have been completed, all rinse fluids should be pumped or poured out of this capturing area and into appropriate storage and transport containers for proper disposal. If no effluent needs to be captured, the diver should be sprayed as he initially exits the water to limit the quantity of contaminants being transferred to the dive station.

Attending technicians should be careful to direct water flow away from potential points of leakage (exhaust valves, seal junctions, etc.) in the diver's rig: a high-pressure jet of water directed at such potential breach points may inject contaminants inside the protective gear and into contact with the diver. Tenders should also exercise care that overspray does not spread contamination. Care should also be taken to remove the bulk of contaminants at this stage to ensure the greatest effectiveness of subsequent decontamination steps.

### 5-3.2 INITIAL EQUIPMENT REMOVAL AND WASHDOWN

As the diver arrives on the dive station following his mission, his oversuit (if applicable) should be cut away to decontaminate the diving rig. This could also be an appropriate time to remove ancillary dive gear such as harnesses, weight belts, emergency gas supply tanks, etc. for subsequent decontamination.

After the diver has been initially rinsed and his ancillary gear and any oversuit removed, the diver should be scrubbed with a stiff-bristle synthetic brush and a cleaning solution. The composition of the cleaning solution should be appropriate for the contaminant to be removed; 5% bleach solutions are adequate for most situations and should not degrade equipment when used for short periods of time and then rinsed away. Commercially available household bleach is usually approximately 5%. One method for preparing a 5% bleach solution is to mix three pounds of HTH (high-test hypochlorite, calcium hypochlorite) into 5 gallons of fresh water. A chlorine-based solution should not be used for cleaning if the contaminants contain appreciable amounts of ammonia. A cleaning solution of 1 to 2% trisodium phosphate (TSP) should work well for such scenarios. Degreasing agents also may be required for adherent, oily residues. One commonly available product for this purpose is Simple Green. Long-handled brushes will facilitate the cleaning process. Hand-held brushes should be used for detailed cleaning of the dive helmet and the neck-dam interface.

Once the diver has been thoroughly scrubbed with cleaning solution applied from head to toe, he should be rinsed with fresh water. Again, attending technicians should be careful when directing high-pressure water toward potential breach points of the diving rig such as exhaust valves, the suit helmet interface, the suit glove interface, zipper, penetrators, etc. They should be careful to ensure that all visible contamination, most notably in the area adjacent to the neck-dam including the dive helmet and the upper portions of the dry suit, is cleaned off the diver. After the diver has received his final rinse, he should progress toward the clean zone.

### 5-3.3 UNDRESS

After the diver has been adequately decontaminated and moved into the "low contamination" zone adjacent to the clean zone, the dive gear should be removed in a stepwise fashion. First, the locking mechanism from helmet to dry suit should be disconnected and the helmet removed. Then the dry suit and gloves should be removed. Next, dive gear undergarments should be removed. If nothing indicates that the diving rig has been breached during the dive, the diver may proceed to the "clean" zone and take a routine postdive shower, which should include washing of the entire body with soap/shampoo. Diver should use Domboro solution in each ear for a minimum of 60 seconds per side. Additionally, the area under each fingernail should be thoroughly scrubbed with soap and a nailbrush. The diver should use antiseptic mouthwash to rinse his mouth. If there are indications of possible dermal exposure to contaminants, then additional decontamination steps will be required. This includes scrubbing the bare skin with a 0.5% bleach solution for approximately 10 minutes and then washing with soap in a shower. The 0.5% solution can be prepared from a 1:9 dilution of the equipment decontamination solution already prepared. Label solutions carefully as applying 5% directly to a diver's skin can be very irritating. Care should be taken not to introduce decontamination solution into abdominal or central nervous system wounds, if present.

All the diver's equipment must undergo secondary decontamination after it has been removed from him during the personnel decontamination procedure. This secondary decontamination procedure entails first rinsing bulk contamination from the equipment and then soaking it in a bleach-based solution for at least thirty minutes. Drums or wading pools may be effective repositories for this process. After soaking, equipment should be rinsed thoroughly until no foaming occurs.

Soaking umbilicals in bleach based solutions is not recommended. An alternative solution such as TSP or a soap such as Simple Green should be used to thoroughly clean umbilicals. Impermeable covers should be applied to avoid introducing cleaning solutions into the interior of diving umbilicals and other air-handling apparatus.

### 5-3.4 TENDER DECONTAMINATION

The tender decontamination procedure is the same as that for divers. The last person out of the contaminated zone will have to self decontaminate.

## 5-4 MEDICAL SUPPORT

After completing a thorough decontamination, individuals should proceed to a medical evaluation station, if appropriate to the hazard. The individuals' vital signs are taken, documented, and compared with the baseline information. Supervisory personnel will be required to make a differential diagnosis between diving related disorders and symptoms related to chemical exposure. These symptoms may overlap making diagnosis difficult. Any individual showing signs or symptoms from exposure or injury should be transported to a hospital for appropriate treatment. Proper documentation on all individuals, methods of decontamination, and any exposures or injuries should be included. Once the individuals leave the medical evaluation area, the decontamination process is complete. The medical treatment after exposure will be conducted in accordance with the specific medical emergency procedures directed by a competent medical team. Again, depending on the type of toxic substance encountered, it may be advisable to introduce short or long term biological and medical surveillance of exposed personnel.

## 5-5 HAZARDOUS WASTE MINIMIZATION

Federal, state, or local regulations may require that residue collected in the decontamination process be collected and disposed of as hazardous waste. This will require prior coordination with local officials to ensure compliance. Every effort should be made to minimize the amount of waste generated consistent with personnel safety.

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# APPENDIX A

## REFERENCE MATERIALS AND INFORMATION SOURCES

29 CFR 1910-120 Occupational Safety and Health Standards - *Hazardous Materials*, http://www.osha.gov.

29 CFR 1910 Subpart T Occupational Safety and Health Standards – *Commercial Diving Operations*, http://www.osha.gov.

*Diving in High-Risk Environments* 3rd Ed., Steven M. Barsky, Hammerhead Press Santa Barbara, CA http://www.marinemkt.com.

National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards - contains general industrial hygiene information on several hundred chemicals/classes for workers, employers, and occupational health professionals. http://www.cdc.gov/niosh.

Registry of Toxic Effects of Chemical Substances (RTECS®), Database of toxicological information compiled, maintained, and updated by the National Institute for Occupational Safety and Health. http://grc.ntis.gov/rtecs.htm - subscription fee required.

Chemical and Biological Defense Information Analysis Center (CBIAC) – Information on chemical and biological warfare agents. http://www.cbiac.apgea.army.mil.

U.S. Army Field Manual (FM) 3-9 *Potential Military Chemical/Biological Agents and Compounds* – available at http://155.217.58.58/atdls.html.

Coast Guard Chemical Hazards Group – maintains the Chemical Hazard Response Information System (CHRIS) database. www.chrismanual.com

Association of Diving Contractors International - www.adc-usa.org.

NOAA Diving Manual, Chapter 13 – *Polluted Water Diving* available through Best Publication company. http://www.bestpub.com/

Armed Forces Medical Intelligence Center (AFMIC) Fort Dietrich MD. https://mic.afmic.detrick.army.mil/.

NOAA Hazardous Materials and Assessment Division – provides tools and information for emergency responders and planners to understand and mitigate the effects of oil and hazardous materials in U.S. waters. http://response.restoration.noaa.gov/

U.S. Environmental Protection Agency
National Health and Environmental Effects Research Laboratory – resource to identify scientific research available on the effects of contaminants on human health. http://www.epa.gov/nheerl/

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